*I*nformation *T*echnology
for Engineering & Manufacturing

Manufacturing Simulation

This presentation describes NIST's role in manufacturing simulation. It gives examples of different types of manufacturing simulation applications that have been developed by NIST researchers and guests. An overview of the technical approach and accomplishments for the Manufacturing Simulation and Visualization Program is also given. A major focus for the current program is the Intelligent Manufacturing Systems (IMS) MISSION Project. The presentation gives background on technical objectives of MISSION, its participants, and the distributed simulation architecture under development for MISSION. The presentation concludes with an overview of the supply chain simulation that is being developed as a test case for IMS MISSION.

Presented by Chuck McLean

Chuck McLean is Leader of the Manufacturing Simulation and Modeling Group in the NIST Manufacturing Systems Integration Division. He is also Program Manager for the Manufacturing Simulation and Visualization Program. He has managed research engineering tool integration, product data standards, and manufacturing automation at NIST since 1982. He has authored more than 40 papers on topics in these areas. He holds a Master's Degree in Information Engineering from University of Illinois at Chicago and Bachelor's Degree from Cornell University.

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Manufacturing Simulation

Chuck McLean
Manufacturing Engineering Laboratory

Topics

- NIST Role
- Background - NIST Simulation Examples
- Technical Approach
- Partners
- Project Examples
- Successes
- Future Plans

NIST Role

Identify, specify, standardize, and test manufacturing simulation data interfaces and modeling techniques that promise to reduce the cost and increase the accessibility of manufacturing simulation technology for U.S. industry.
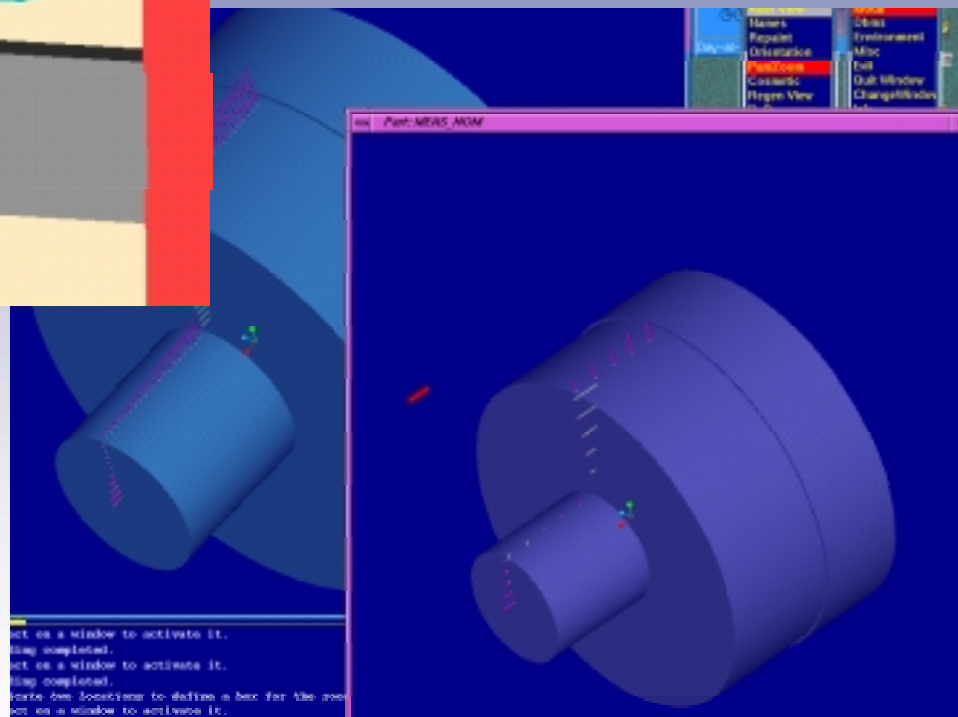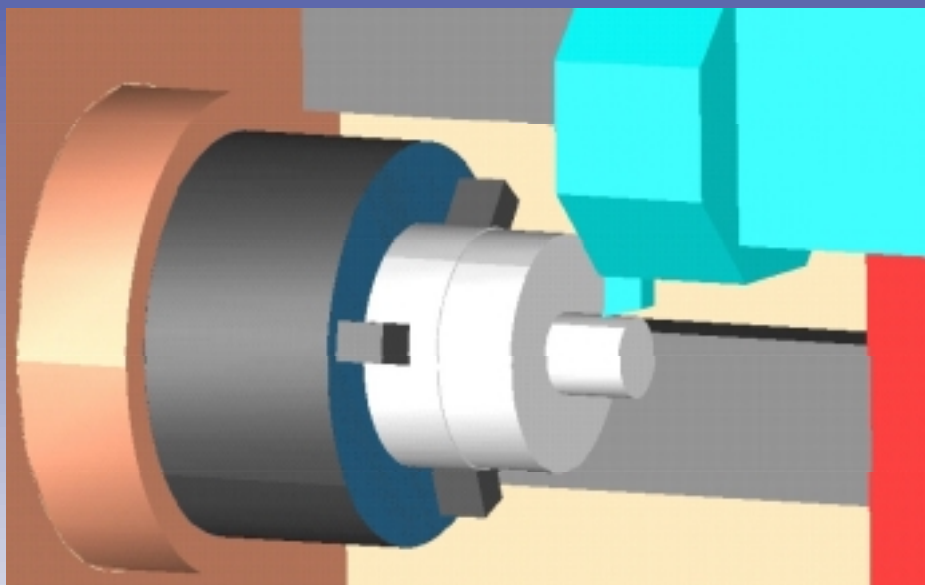
Background

Examples of NIST Simulation Work

- Manufacturing Engineering Tool Kit - design, process planning, machine tool programming, and NC validation through simulation

- Machine Tool Modeling - modeling of errors and prediction of machine tool performance

- Production System Engineering - material flow, production line layout, and mechanical assembly process

- Ergonomic Modeling - simulation of manual assembly operations

- Manufacturing Supply Chain - integration of a personal computer manufacturing supply chain

- Shipyard Simulation - discrete event model of steel fabrication using time study data
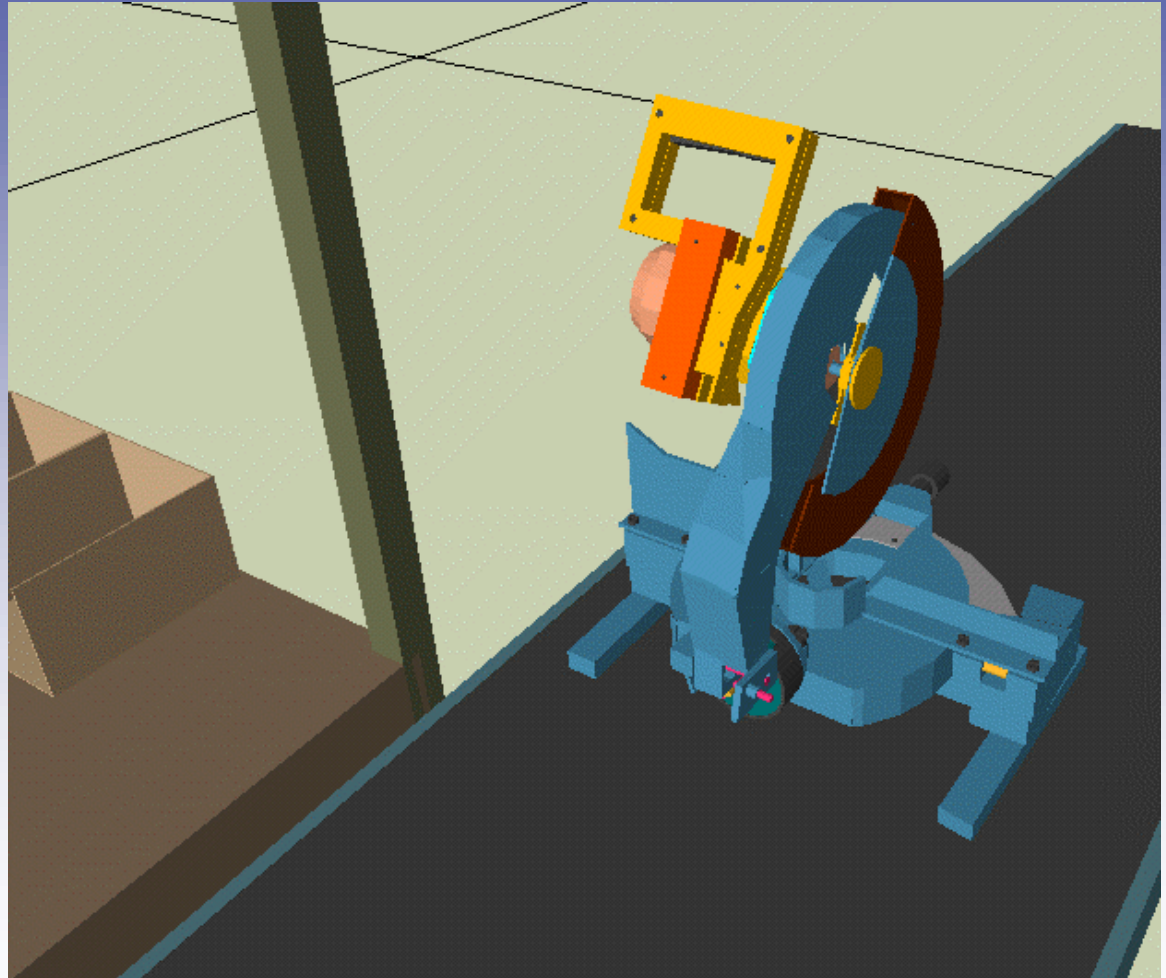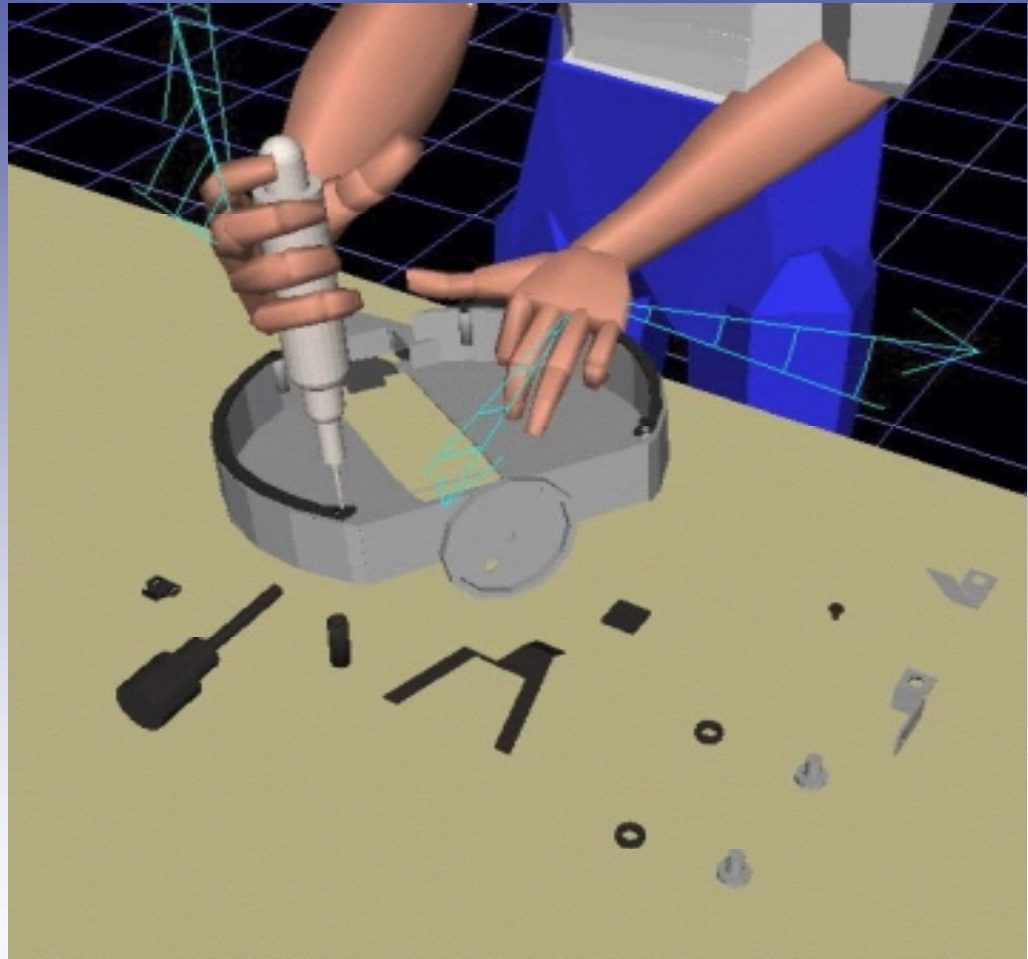
Manufacturing Engineering Tool Kit
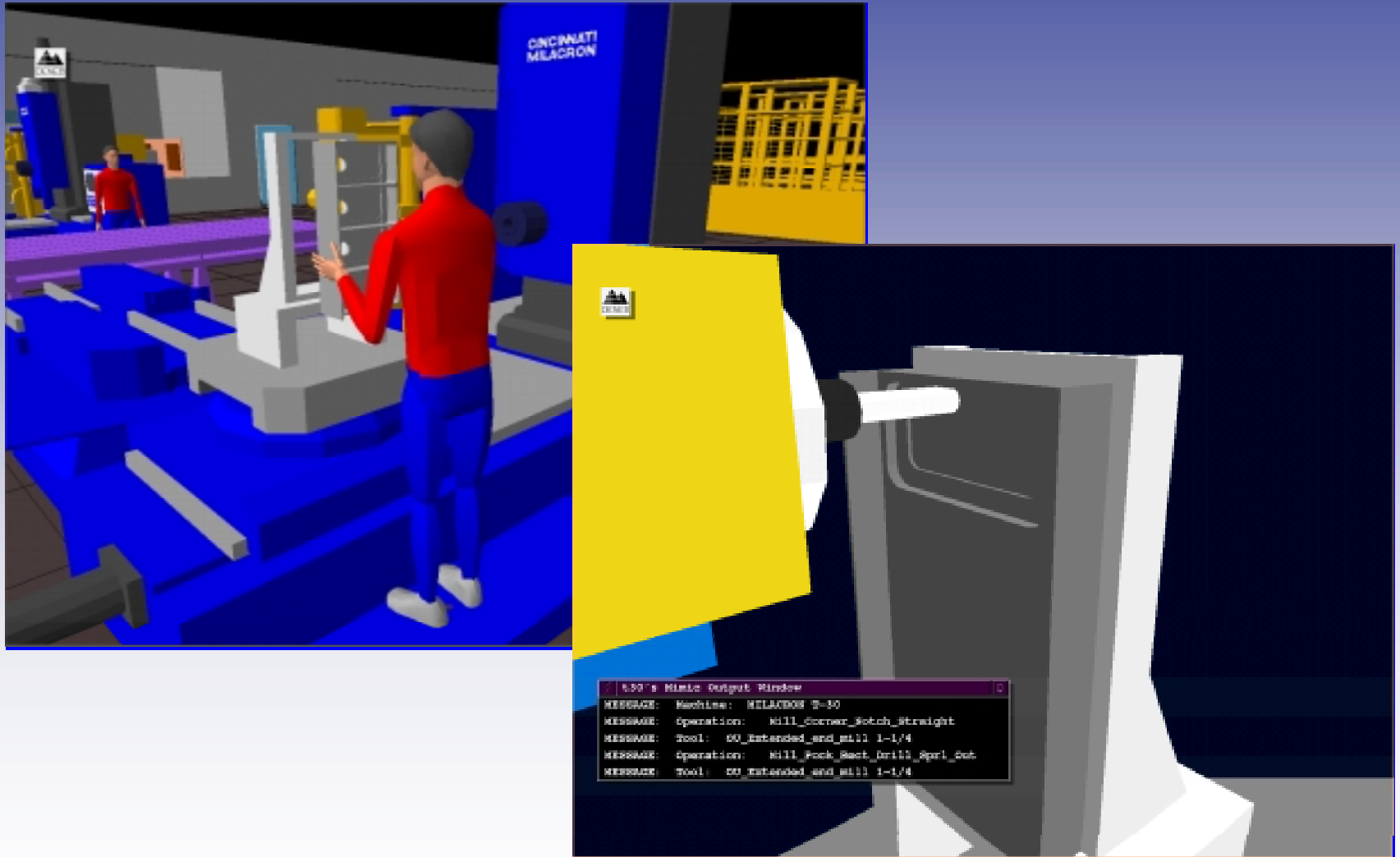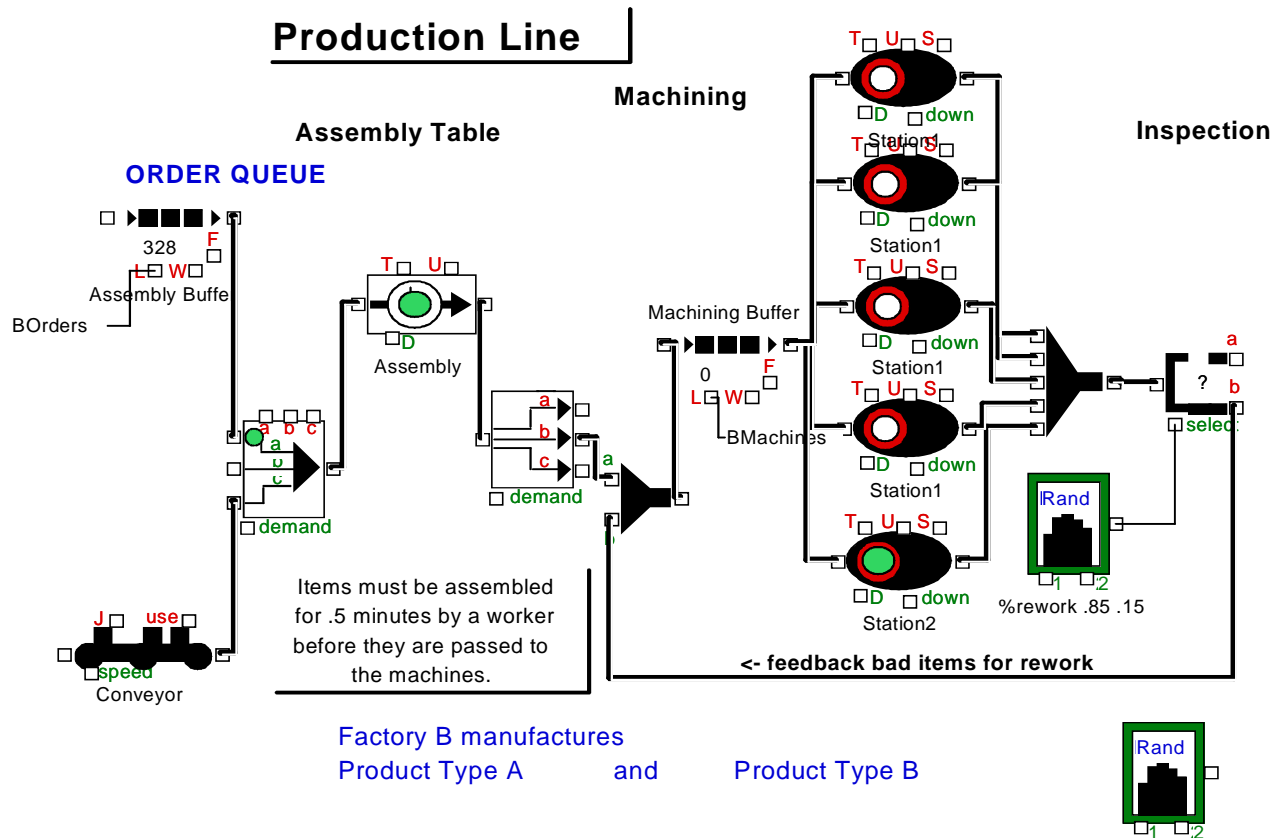
Machine Tool Error Modeling

Production System Engineering

Ergonomic Modeling

Manufacturing Supply Chain

Production Line

Assembly Table

Machining

Inspection

ORDER QUEUE

328

Assembly Buffer

BOrders

Assembly

Items must be assembled for .5 minutes by a worker before they are passed to the machines.

Conveyor

Machining Buffer

0

BMachines

Station3

Station1

Station1

Station1

Station2

%rework .85 .15

Rand

<- feedback bad items for rework

Factory B manufactures
Product Type A   and   Product Type B

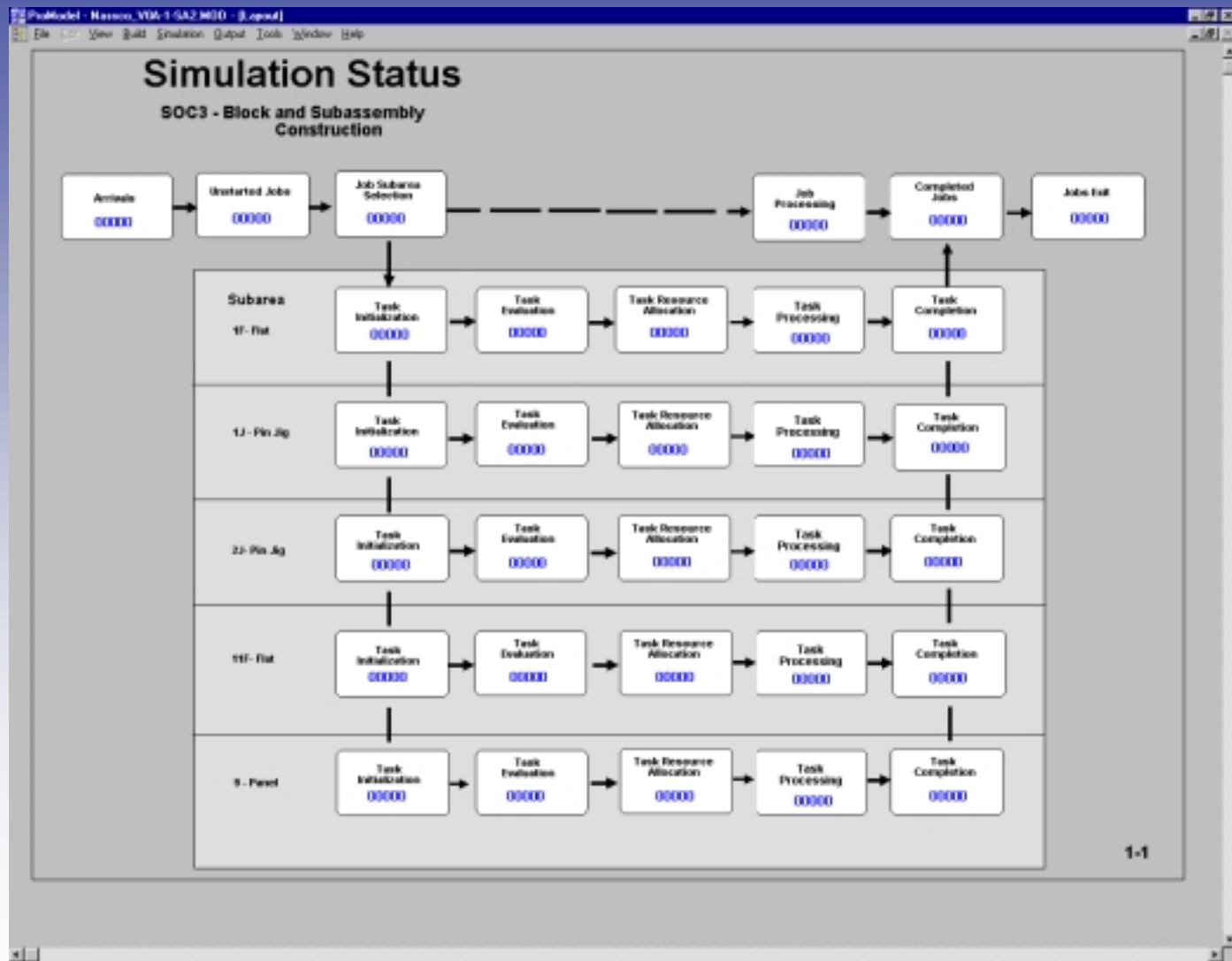Rand

Material Flow Analysis
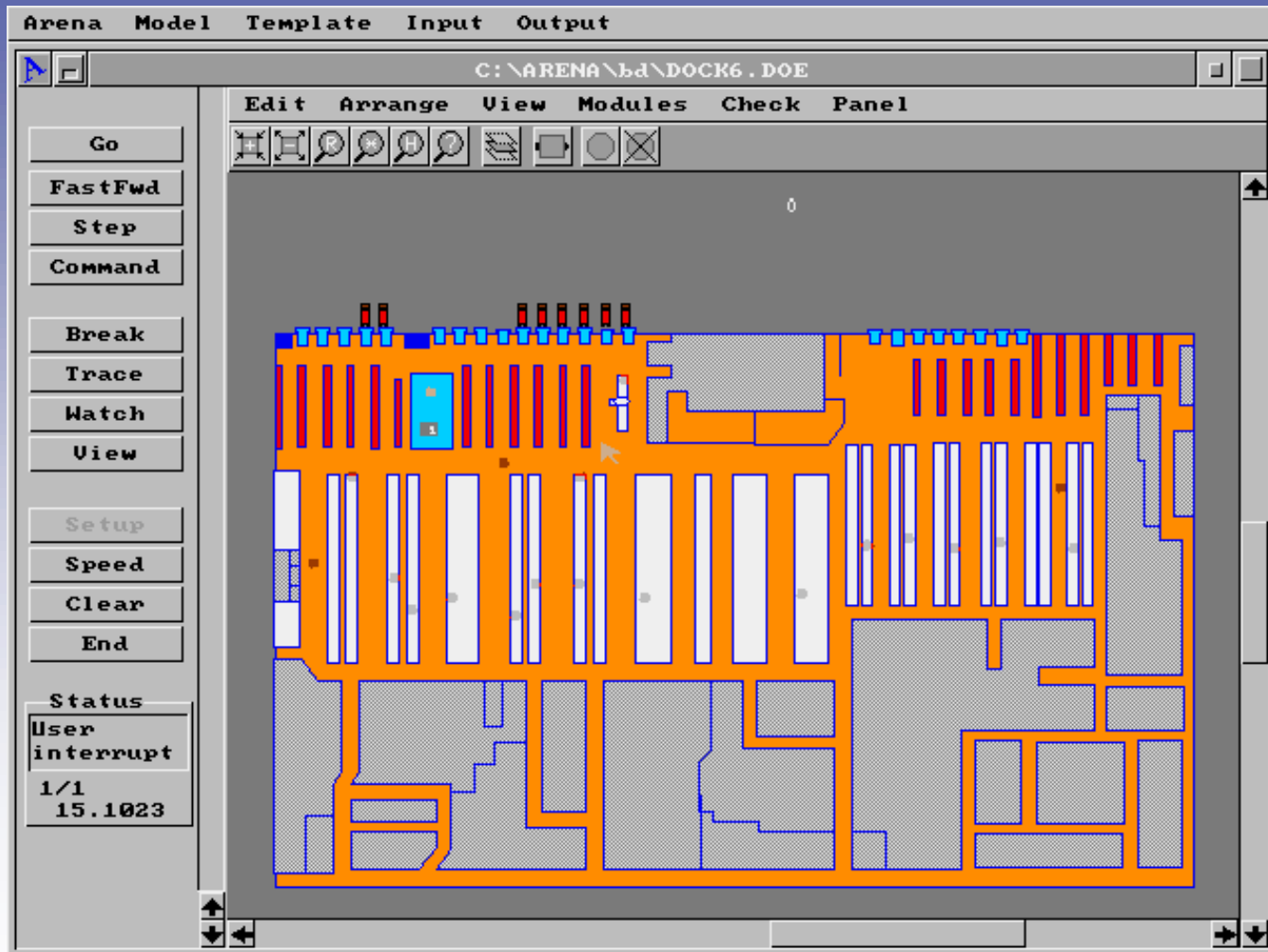
Shipyard Time Study Simulation

Technical Approach

- Identify simulation and engineering tool integration requirements from hands-on experience with software tools, interactions with users and vendors, and industry road-mapping activities

- Capture relevant definitions, theory, algorithms, and data models as part of the science of manufacturing system integration

- Develop draft interface specifications of production scheduling, layout, machine modeling, machining and assembly process plans using the IMES methodology to advance the near term interoperability of engineering, simulation, and production management applications

- Implement test beds and proof-of-concept demonstrations to show the feasibility of candidate specifications

- Work with IMS MISSION and Object Management Group SIMSIG to develop define, evaluate, test, and promote candidate standards

- Work with NASSCO and Atlantic Marine Shipyards to develop prototype simulation solutions for U.S. shipbuilding industry under the National Shipbuilding Research Program

Simulation Partners

Government

- NIST
- Defense Modeling Simulation Office

Software Vendors

- Autosimulations
- Deneb Robotics
- Engineering Animation Inc. (EAI)
- Knowledge Based Systems Inc. (KBSI)
- Micro Analysis and Design
- Nyamekye Research and Consulting
- Pritsker/Symix Corporation
- ProModel Corporation
- Systems Modeling Corporation
- Tecnomatix Technologies

Industry

- Black and Decker
- NASSCO Shipyard
- Atlantic Marine Shipyard

Academia

- Arizona State University
- Florida International University
- Iowa State University
- Pennsylvania State University
- Virginia Polytechnic Institute
- University of Illinois
- University of Maryland
- University of Tennessee

Technical Accomplishments

- Established test bed of commercial simulation tools and test data
- Developed models and draft specifications for discrete event simulation, validation methodology, and workstation process plans
- Participated in IMTR road-mapping activities in modeling and simulation
- Initiated joint simulation interface specification development activities with international IMS MISSION Project and OMG Distributed Simulation Special Interest Group
- Developed distributed manufacturing simulation architecture for IMS MISSION Project
- Developed a number of prototype manufacturing simulations including shipyard models, manual assembly of Black and Decker miter saw, and Makino high speed machining center for validation of NC data packages
- Implemented prototype manufacturing engineering tool kit

Intelligent Manufacturing Systems Program

- **IMS is an industry-led, international R&D program established in 1995 to develop the next generation of manufacturing and processing technologies.**

- **IMS povides a support structure for conducting R&D projects within specific arrangements for the protection of intellectual property rights.**

- **NIST provides the Secretariat for the U.S. Region.**

- **See www.ims.org for further details**

IMS MISSION Project

Modeling and Simulation Environments for Design Planning and Operation of Globally Distributed Enterprises

– **integrate and utilize new, knowledge-aware technologies of distributed persistent data management, as well as conventional methods and tools, in various enterprise domains, to meet the needs of globally distributed enterprise modeling and simulation.**

IMS MISSION Outlook

- **MISSION expects to produce:**

    - increased interaction among vendors regarding simulation issues

    - better understanding by vendors of manufacturers' simulation needs

    - demonstrations of integration of globally distributed components

Scope of distributed manufacturing simulation

1) **Multiple simulation software processes that are independently executing and interacting with each other. Software may have been developed by different software vendors. Modules may run on different computer systems in geographically dispersed locations.**

2) **A distributed computing environment where other non-simulation manufacturing software applications are running and interacting with one or more simulation systems. Engineering systems may interact with simulation systems through service requests.**

3) **A distributed manufacturing simulation system comprised of multiple functional modules that together form a system, such as model builders, simulation engines, display systems, analysis tools, etc.**
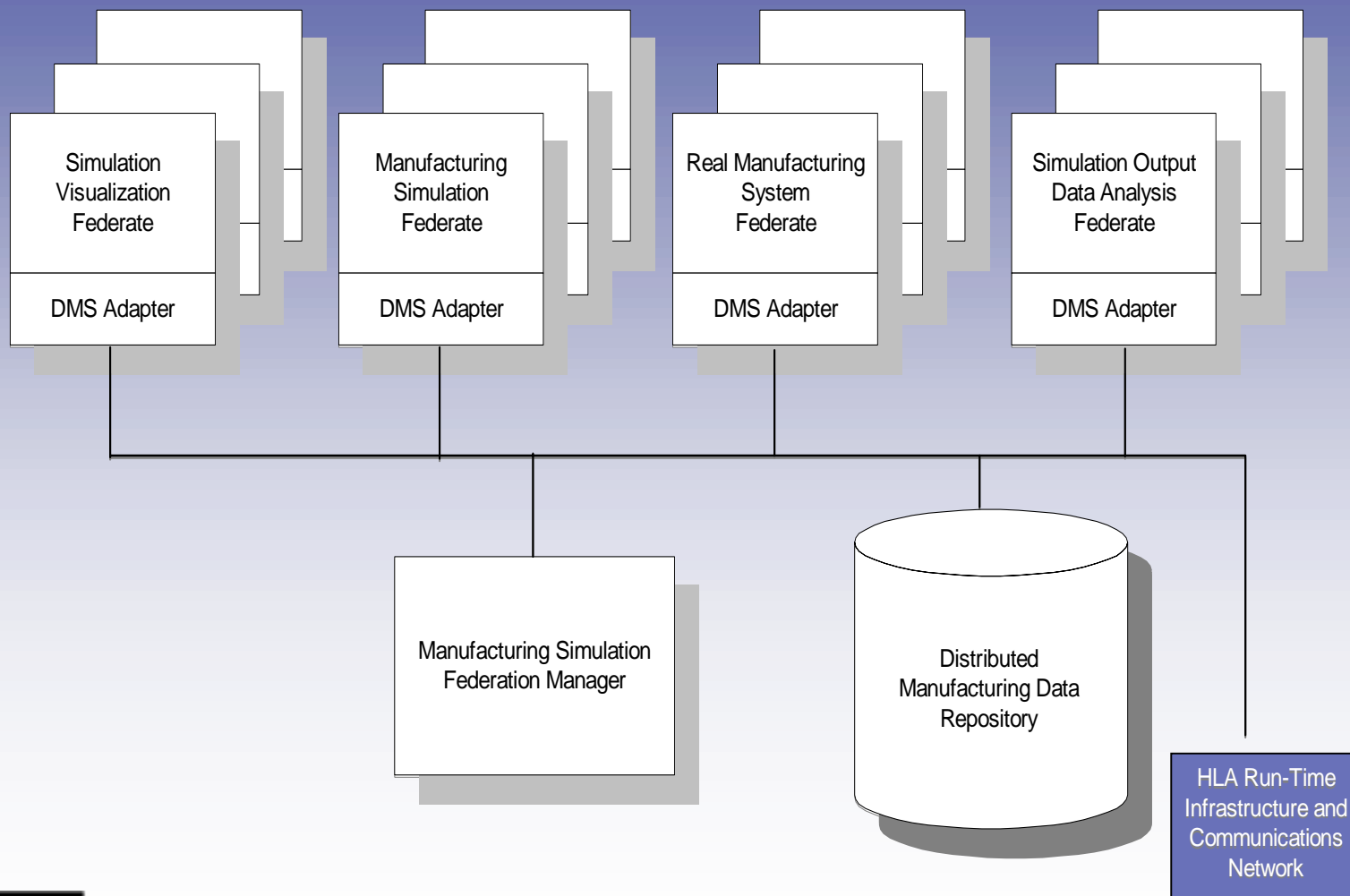
Why build distributed manufacturing simulation systems?

- **Model supply chains across multiple organizations where some of the information about the inner workings of each organization may be hidden from supply chain members**

- **Model multiple levels of manufacturing systems where lower level simulations generate information that feeds into higher level models**

- **Multiple types of systems in a single factory with different simulation requirements such that an individual simulation vendor's product does not provide the capabilities to model all capabilities of interest**
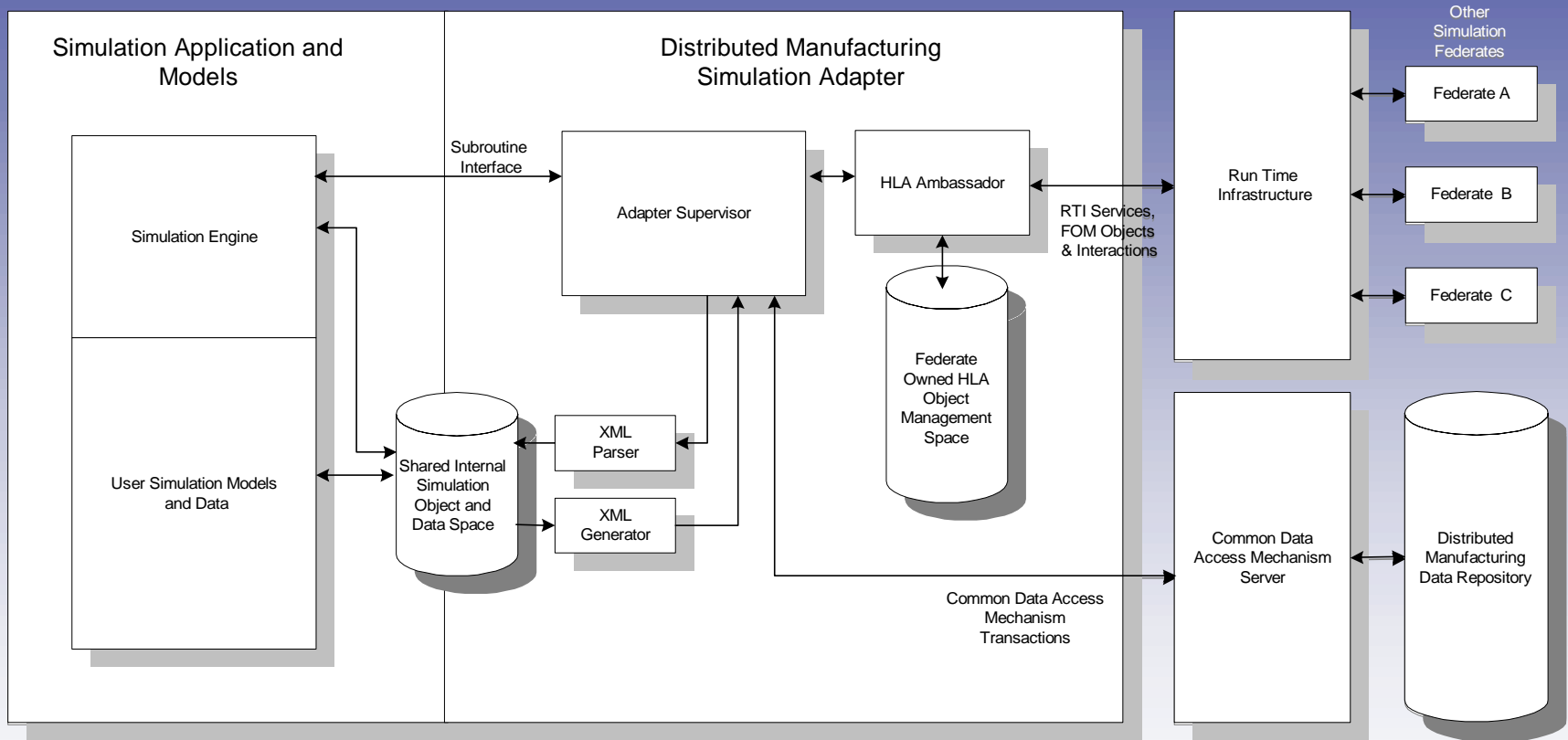
More reasons to build …

- Hide proprietary information about the internal workings of a simulated system, e.g., an equipment vendor might hide information via run-time simulation models

- Create low-cost run-time simulation models with limited functionality that can be integrated into larger simulations

- Take advantage of additional computing power afforded by distributing execution across multiple processors

- Provide simultaneous access to models for users in different locations (support remote collaborative work)

- Provide different numbers and types of licenses for different functions supporting simulation activities (model building, visualization, execution, analysis)
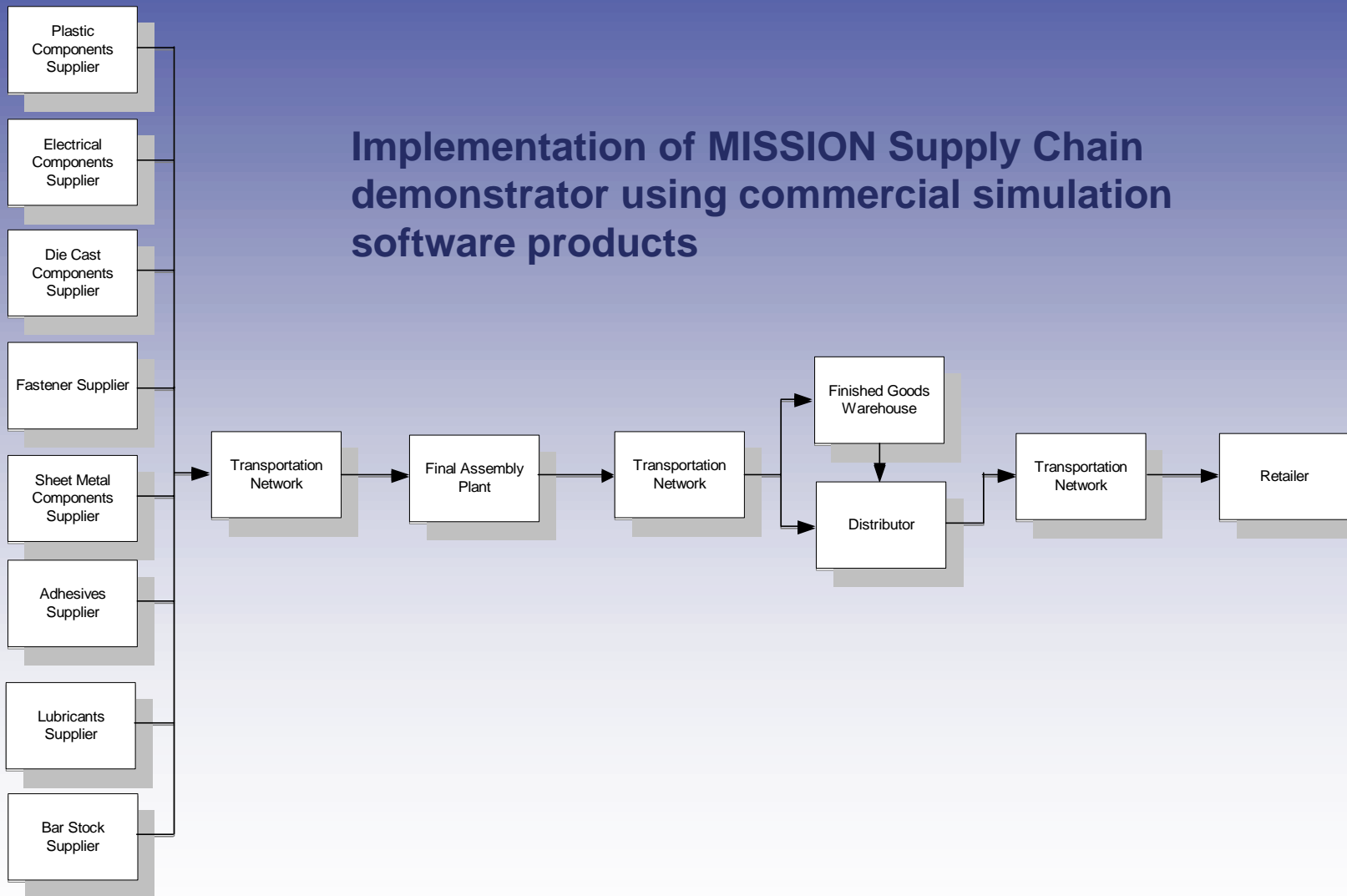
Distributed Manufacturing Simulation

Simulation Federate

Future Plans

Plastic Components Supplier

Electrical Components Supplier

Die Cast Components Supplier

Fastener Supplier

Sheet Metal Components Supplier

Adhesives Supplier

Lubricants Supplier

Bar Stock Supplier

Implementation of MISSION Supply Chain demonstrator using commercial simulation software products

Transportation Network → Final Assembly Plant → Transportation Network → Finished Goods Warehouse → Distributor → Transportation Network → Retailer

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